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Ranga-Ram Chary, Harry I. Teplitz, Kartik Sheth, eds.

Unification of 3CR Radio Galaxies and Quasars

Bernhard Schulz

California Institute of Technology, IPAC, M/C 100-22, Pasadena, CA 91125, USA

Ralf Siebenmorgen

European Southern Observatory, Karl-Schwarzschild Str. 2, D-85748 Garching, Germany

Martin Haas

Astronomisches Institut, Ruhr Universität, Universitätsstr. 150, D-44780 Bochum, Germany

Endrik Krügel

MPI für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

Rolf Chini

Astronomisches Institut, Ruhr Universität, Universitätsstr. 150, D-44780 Bochum, Germany

Abstract. With the Spitzer IRS (Houck et al. 2004) we have observed seven powerful FR2 radiogalaxies and seven quasars. Both samples are comparable in both, isotropic 178 Hz luminosity and redshift range. We find for both samples similar distributions in the luminosity ratios of Mid-IR high- and low-excitation lines ([NeV]/[NeII]), and of Mid-IR high-excitation line to radio power ratio ([NeV]/$P_{178\,\mathrm{MHz}}$). We further observed Silicate features at 10 and 18 μm in emission. Emission features are limited to the quasar group, while silicate absorption is seen only in the radio galaxies. These observations are all in agreement with unification schemes that explain both groups as the same class of objects seen under different orientation angles.

1. Introduction

According to unification schemes, quasars (Type 1 AGN) and powerful radio galaxies (Type 2 AGN) are the same phenomenon seen from different aspect angles. A dusty molecular torus blocks the line of sight to the central engine and the broad line region when seen from the side. Narrow high ionization lines are seen in both AGN types and are thought to originate outside the torus. The same is certainly true for the radio emission originating from the lobes of the radio jets. The radio power is a measure for the total energy output of the AGN, and is correlated to the FIR luminosity (Meisenheimer et al. 2001).

2. Sample Parameters

The subsamples consist of 7 FR2 radio galaxies and 7 quasars (see Table 1). They are comparable in isotropic 178 MHz luminosity ($10^{26.5}$ W/Hz $\leq P_{178\,\mathrm{MHz}} \leq 10^{29.5}$ W/Hz) and redshift ($0.05 \leq z \leq 1.5$). Histograms of the distributions are shown in Figure 2. The selection was taken from a subsample of the 3C catalogue, previously observed with ISO (Siebenmorgen et al. 2004; Haas et al. 2004) that had sufficient S/N and were not blocked by Spitzer guaranteed time reservations.

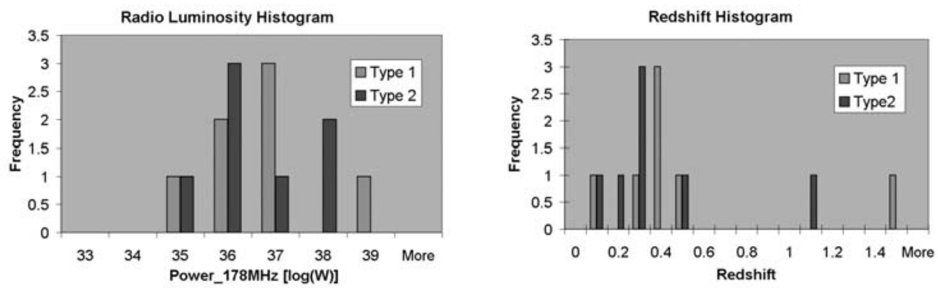

Figure 1. Luminosity and redshift distributions of both samples.

3. More Dust Reddening in Radio Galaxies

Both samples show similar high to low excitation line ratios ([NeV]/[NeII]) and are statistically indistinguishable, as expected for AGN (Genzel et al. 1998). The MIR/FIR luminosity, however, is generally higher than for FR2 radio galaxies. If the FIR luminosity is correlated to the AGN power, as suggested by Meisenheimer et al. (2001), then the MIR/FIR ratio hints at substantial dust absorption in FR2 galaxies, since the radio powers of both AGN types in the sample are similar. For a diagram see Haas et al. (2005).

4. How Isotropic is Emission at Visible Wavelengths?

Both samples show similar ratios of [NeV] and radio emission. FR2 galaxies show more attenuated visual $[\mathrm{OIII}]_{500.7\ \mathrm{nm}}$ line emission compared to the infrared [OIV] line, than quasars, probably due to dust absorption. We conclude therefore that the $[\mathrm{OIII}]_{500.7\ \mathrm{nm}}$ line is not a good isotropic tracer for testing unification schemes in high luminosity objects.

5. Silicate Emission

In many of the type 1 AGN we find a broad bump between 9 and 13 μm and a smaller bump at 18 μm. We interpret these as emission by Silicates. We find a clear correlation of silicate emission with AGN type 1 and absorption with AGN type 2 (see Table 1).

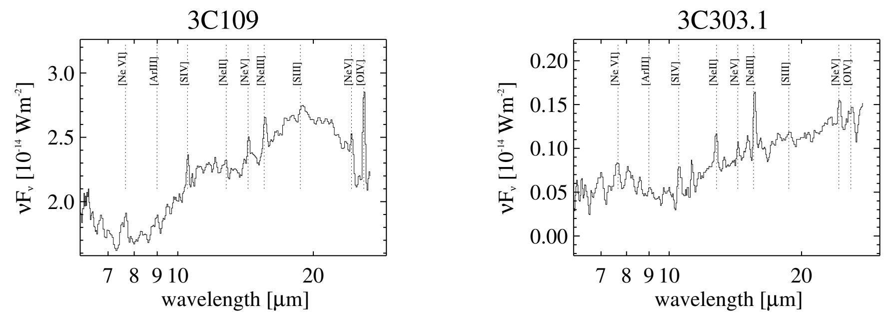

Figure 2. Example spectra of a quasar and a radio galaxy showing the characteristic Silicate features.

Table 1. Sample parameters: The first 5 columns are taken from Haas et al. (2005). The abbreviated types are QSR=quasar, BLRG=broad line radio galaxy, NLRG=narrow line radio galaxy. The luminosity distance D_L is computed adopting a Λ-cosmology with $H_0 = 70\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, $\Omega_m = 0.27$ and $\Omega_\lambda = 0.73$. $P_{178\,\mathrm{MHz}}$ is the radio power at 178 MHz. The last column indicates whether silicate in absorption or emission was detected.

Name	Type	z	D_L [Mpc]	$P_{178\,\mathrm{MHz}}$ log[W]	Silicate
3C079	NLRG	0.256	1283	36.08	absorption
3C295	NLRG	0.461	2559	37.15	no det.
3C303.1	NLRG	0.267	1347	35.55	absorption
3C321	NLRG	0.096	435	34.76	absorption
3C356	NLRG	1.079	7296	37.27	no det.
3C381	NLRG	0.160	758	35.34	no det.
3C459	NLRG	0.220	1081	35.85	absorption
3C047	QSR	0.425	2322	36.56	no data
3C109	BLRG	0.306	1577	36.12	emission
3C249.1	QSR	0.311	1607	35.83	emission
3C298	QSR	1.436	10427	38.24	no det.
3C323.1	QSR	0.264	1329	35.61	emission
3C351	QSR	0.371	1975	36.13	emission
3C445	BLRG	0.056	247	34.52	no data

6. AGN Dust Model

A dust model by Pier & Krolik (1992) predicted Silicates in both absorption and emission. ISO observations showed only Si absorption due to limited wavelength coverage. Spitzer IRS finds the Si feature in AGN also in emission (Siebenmorgen et al. 2005; Hao et al. 2005).

The ≈11 μm bump can be modelled by optically thin emission of Silicate dust with 3 radiating components and a primary powerlaw spectrum source radiating at 0.1-15 μm (α=-0.7). The position shift of the emission feature is explained by the folding of the Silicate absorption coefficient with the steeply rising Planck function. We assumed a standard galactic dust mixture of carbon and silicate spheres of 0.1 μm radius with optical constants by Zubko, Dwek & Arendt (2004) and cross sections calculated from Mie-theory.

7. Conclusions

- We have taken low resolution Spitzer IRS spectra of a sample of powerful radio galaxies and quasars, comparable in 178 MHz luminosity and redshift range.
- High to low ionisation line ratios in the MIR classify both object types as AGN. [NeV]/[NeII] ratios and [NeV]/$P_{178\,\mathrm{MHz}}$ ratios are found similar in type 1 and 2 objects as required by unification schemes.
- The visual [OIII] line is not a good isotropic tracer for testing unification schemes in high luminosity objects.
- Silicate emission has been observed in extragalactic sources, and is seen only in type 1 AGN, fulfilling a prediction by unification schemes.
- The SED can be modeled by a simple 3 component dust model without postulating exotic grain sizes, abundances, or dust cloud geometries.

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